CALUMET INTERCEPTING SEWER 19F REHABILITATION

By: Frederick Wu, Metropolitan Water Reclamation District of Greater Chicago
Carmen Scalise, Metropolitan Water Reclamation District of Greater Chicago
Kevin Fitzpatrick, Metropolitan Water Reclamation District of Greater Chicago
Kevin Coburn, Insituform Technologies USA, LLC

1. BACKGROUND INFORMATION

The Metropolitan Water Reclamation District of Greater Chicago (District) is located primarily within the boundaries of Cook County, Illinois. The District serves an area of 883.6 square miles which includes the City of Chicago and 125 suburban communities. The District serves an equivalent population of 10.35 million people; 5.25 million real people, a commercial and industrial equivalent of 4.5 million people and a combined sewer overflow equivalent of 0.6 million people. The District's 560 miles of intercepting sewers and force mains range in size from 8 inches to 27 feet in diameter, and are fed by approximately 10,000 local sewer system connections.

2. INTRODUCTION

Calumet Intercepting Sewer 19F (Cal-19F) was constructed in 1970 by the District to provide an outlet to sanitary sewers serving parts of the Villages of Tinley Park and Oak Forest. The sewer was constructed in anticipation of the rapid suburban expansion of the southwest side of Cook County. The sewer consists of 14,051 feet of 60-inch diameter concrete pipe, 24 manholes and 1 connecting structure (Figure 1). The interceptor receives industrial, commercial and residential flow from approximately 15.69 square miles in the southwest suburbs of Chicago with a design population of 110,000.

Video inspection and surface inspection of the sewer, manholes and structures was performed by the Maintenance and Operations Department in 2008, 2011 and 2014. The inspection of the MWRD facilities revealed concrete erosion had occurred extensively due to the action of the hydrogen sulfide and high flow velocity in the sewer. Due to the depth of the sewer (35-70 feet below grade) and high flows, physical inspection of Calumet 19F was not feasible without extensive safety precautions and bypass operations.

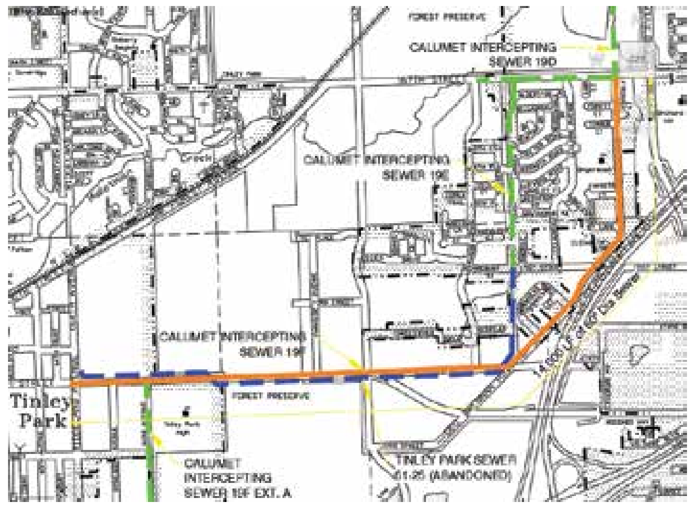

Figure 1. Calumet 19F Location Plan

3. DESIGN

The initial inspection provided by the Maintenance and Operation Department led the District to initiate a contract to rehabilitate the sewer, manholes and structure.

The District reviewed as-built drawings, construction documents, flow data, sewer layouts and surrounding sewer systems. As-built drawings show the sewer depth between 30 and 70 feet below grade and the sewer was originally constructed by tunneling. Flow data was collected over a 5-month period and the data showed maximum flows that exceeded 30 MGD. Review of the MWRD sewer atlases and local municipal sewer atlases didn't reveal any viable diversion route for flow entering into the sewer.

In anticipation of the large expenditure associated with a bypass system, the District specified that any lining be designed for fully deteriorated conditions to ensure maximum longevity. Since the sewer was originally constructed by tunneling, the district specified tunnel-loading conditions. By specifying a tunnel-loading condition, the total calculated design load would be reduced and the resulting liner would be thinner.

Based on the information collected, the District realized that a bypass system would be required to perform lining of the sewer. The District specified two different technologies for the lining of the sewer; cured-in place pipe lining and slip lining, with the understanding that CIPP would require a full flow bypass system for the entire duration of the lining process and slip lining would require a partial bypass system during lining. However any cost savings with the reduced bypass system for slip lining had the potential to be offset with the installation of multiple insertion shafts greater than 30 feet deep.

Based on the length of the sewer being rehabilitated, many stakeholders were going to be impacted by lining. The District acquired right of way from the following entities: Cook County Department of Transportation, Bremen Township, City of Oak Forest, Village of Tinley Park and Forest Preserve District of Cook

County. The District also contacted directly impacted entities like local residents, Panduit Corporation, Tinley Park High School and Morton-Gingerwood Elementary.

4. CONSTRUCTION

Insituform Technologies USA, LLC (Chesterfield, MO) was awarded the contract for $12.4M. The scope consisted of installing cured-in-place pipe (CIPP) to rehabilitate 14,051 feet of 60-inch pipe, rehabilitating 24 manholes and one junction chamber. The CIPP installation plan was a hybrid approach using both traditional CIPP and composite CIPP, offering several advantages. Before construction began, much time was spent planning the bypass capacity, design and layout. This extensive bypass system necessitated good communication with the many entities where the pipe would be laid and the impact to their daily routines.

Bypass

Roughly one-third of the bid cost was associated with an extensive bypass system. The challenge to this bypass system was an invert depth of 45 feet at the suction point, a discharge length of 14,000 feet and meeting a dry weather flow volume of 15 MGD daily with peak flows in excess of 30 MGD which primarily comes from a 20-inch force main. A benefit of bypassing the entire 14,000 feet of 60-inch in one long set up meant there was no downtime between CIPP installations while waiting to shift the bypass. When considering heavy residential traffic, road bores, railroad track easements, business driveways and a school, it becomes clear why the bypass was a controlling factor for this project. To meet these demands, Mersino (Davidson, MI) installed twin 18-inch vertical turbine pumps at the bypass pumping station near 175th and Ridgeland in Tinley Park (Figure 2). These turbines pumped through 2,700 feet of twin 32-inch HDPE pipes to a booster station with two 24-inch global 10,000 GPM high head trash pumps. From the booster station (Figure 3), the flow continued another 11,300 feet to the discharge point.

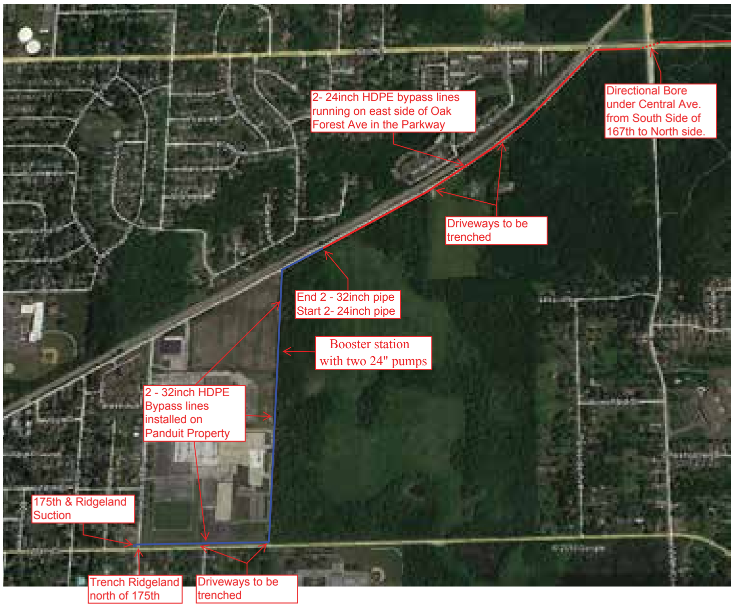

Figure 2. Bypass Routing

Lining of large diameter sewers that are 35-70 feet below ground creates problems that aren't present in typical 10-foot deep sewers.

At the bypass pumping station, a new electric service drop was installed to save money on fuel costs. Generators were on site as a back-up measure and they were only used twice during the duration of bypass. From the bypass pumping station, the bypass route runs along the south side of the Panduit property and the twin 32-inch HDPE pipes were to lay just behind the fence line. Due to the timing of a pond beautification project taking place on the property, there wasn't room to lay the pipe behind the fence. The sidewalk in front also wasn't available due to foot traffic from students walking to their school that was ¼ mile away. Tinley Park agreed to build a new sidewalk on the other side of the street for students to utilize. The new sidewalk had been in planning for a while, however this work was the impetus needed. This new sidewalk on the south side of the street cleared the way for the bypass piping to be laid on the sidewalk on the north side of the street. The bypass pipe then turns north and runs along the east side of Panduit to the booster station.

Figure 3. Booster Station

The booster station was designed to take the pressure off the amount of work the vertical turbines needed to do. The booster pumps were originally designed to be used during dry weather flows, but the turbines performed so well, the boosters were only used 3-4 times during wet weather events. After the flow travelled through the booster station, there was a 400-foot stretch along the forest preserve and the original plan was to set the twin 24-inch HDPE pipes on the walking path. The permit by the forest preserve wouldn't allow any bypass material on the walking path. To get the pipes through, Airy's Inc. (Tinley Park, IL) made 26 cantilevered "H" beams and hydro excavated 5 feet into the ground in the narrow space between the wooden fence and the road (Figure 4). Once installed, they poured flowable fill around the beam to stabilize it. The HDPE pipes were then stacked vertically and secured to the "H" beams to get through this narrow area. The existing structure for a discharge point was in a protected wetlands area and couldn't be used. Instead, a 50 foot deep cast in place concrete structure was installed in the forest preserve parkway. This structure is available as a future access point, but it was buried at the conclusion of the project.

Figure 4. Cantilevered "H" beam used to stack 24" HDPE for bypass

The Village of Tinley Park requested that the water level in the bypass structure (which contained the turbines) would dictate how many pumps would run at the Tinley Park pump station with the 20-inch force main. Sensors and transducers were installed at the bypass pumping structure and were tied in with a control panel which then controlled the pumps at the Tinley Park pump station. This allowed the system to slow down if the bypass wasn't keeping up and would also send an alarm. This bypass system was set up for a total of 10 months and proved to be well designed and built. During one rain event this bypass system pumped a flow of 23,000 GPM (33 MGD) without issue. Roughly 85 per cent of the time just one vertical turbine would take care of the daily flow and push it nearly 3 miles with no help from the second turbine or the booster station. The system allowed the work to continue even when flows were well beyond dry weather volumes and for extended periods of time.

CIPP Design – Composite Technology

Due to the large diameter and depth of this sewer, the ASTM F 1216 formulas yielded thick liner designs. If traditional CIPP was used for the entire project, many of the 24 installations would have been too heavy to transport the wetted out tube to the jobsite. Therefore, it would have required the felt liner to be wet out onsite as it was being installed. To eliminate any need for on-site wet out for the deeper and longer installations, composite technology was utilized. A fiber-reinforced CIPP liner resulted in a thinner design which allowed the liner to be transported direct from the wet out facility to the jobsite. The improved physical properties of fiber-reinforced composites applied to cured-in-place pipe reduce the wall thickness required to withstand the design loads.

Cured-in-place composite pipes with thinner walls require less resin and weigh less. Thinner tubes also reduce the difficulties associated with handling the dry tube during manufacturing. Further, the logistical challenges during resin impregnation are reduced due to the smaller volume of resin to be processed and the reduced weight to be handled at a wet out facility.

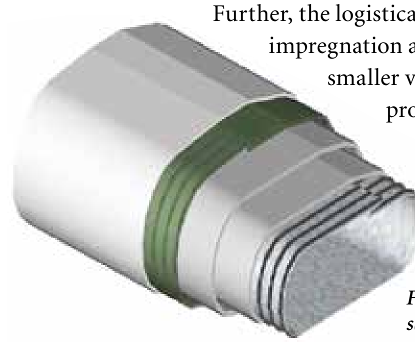

Figure 5. Fiber reinforced sandwich technology

Fiber-reinforced products have been engineered to take advantage of the material properties offered by fiber-reinforced plastics. The stiffness of a laminated, or sandwich beam, is determined by the material properties and second moment of inertia of each layer - its area times the square of the distance from the neutral plane (Figures 5 & 6). A sandwich composite beam is constructed by bonding a layer of very stiff material to each side of a "core" layer with relatively low material properties. (Hahn, 2007)

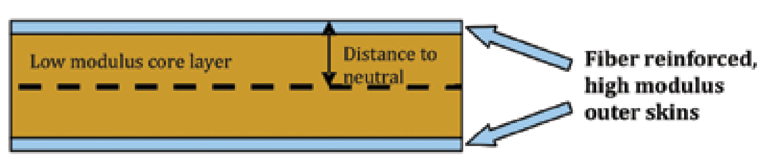

Figure 6. Composite "Sandwich" Technology

In fiber-reinforced CIPP, the core material is most commonly polyester resin and felt, with a flexural modulus of 250,000 to 400,000 psi, similar to that or a standard CIPP liner. Layers of a cured-in-place pipe with increased strength are produced by incorporating reinforcing fiber into the polymer matrix. Glass or carbon fibers are commonly used as reinforcement in sandwich composite beams. To compare the two options, a layer reinforced with glass fiber may have a flexural modulus as high as 10 million psi, and one with carbon fiber flexural modulus may be 20 million psi. In practice, the optimum amount of fiber is designed into the composite beam to achieve the desired design stiffness.

The fibers are incorporated by layering them with polyester felt. These fabrics are added to the construction of the tubes during the normal manufacturing process. One layer of reinforcement is situated close to the surface of the host pipe with the other layer close to the inner surface of the CIPP (Figure 7) for a cross-section view of the fiber reinforced pipe.

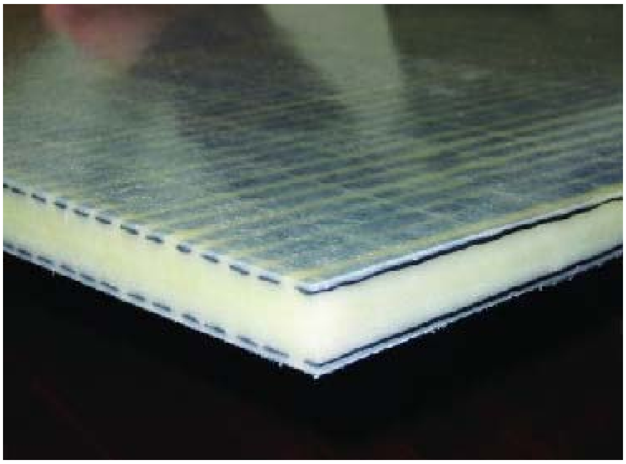

Figure 7. Cross-section view of fiber reinforced pipe

CIPP Installation

It took 24 separate installations to complete the 14,051 feet of 60-inch lining. This meant a minimum of 12 manholes would be required to perform the 24 installations if the liners were "shot" both directions from each manhole. Due to site conditions, 14 manholes were used to install the 24 liners. Each of the manholes are 48-inch diameter, which made the 60-inch liner a tight fit. In order to invert the liner thru the existing manhole, the steps, rest platforms and frame and cone were removed. A 48-inch barrel section was then installed to bring the manhole back to grade. Finally, a stone landing pad with wood planks was built to ensure there was a level installation platform at all 14 manholes to allow for proper installation.

5. CONCLUSION

A few lessons were learned during the planning and execution of this contract. Providing flow data during the bidding phase allowed the contractor to properly size bypass pumps. This resulted in lower bid price that more accurately reflected the true cost associated with flow bypass.

We also learned that the use of a temperature sensor for larger diameter CIPP lining jobs can be beneficial. The additional cost of a temperature sensor for a large diameter CIPP installation is minimal compared to the data provided to both the owner and the contractor. A temperature sensor can help the contractor know exactly when the exothermic reaction has occurred, which allows the official cure cycle timer to begin. This knowledge can result in valuable savings and provide the owner with live objective data to ensure the liner has properly been cured.

Additionally, lining of large diameter sewers that are 35-70 feet below ground creates problems that aren't present in typical 10-foot deep sewers. The bypass required on this project was a massive undertaking. This project shows that good engineering, proper planning and communication between all parties during the build out of a project can produce successful results on a difficult project.

6. REFERENCES

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ABOUT THE AUTHORS:

Frederick Wu *is a Senior Civil Engineer for the MWRDGC engineering department. Frederick specialized in design, rehabilitation and management of the District's collection system. Frederick holds a M.S. in Environmental Engineering from Illinois Institute of Technology and a B. S. In Civil and Environmental Engineering from University of Illinois Urbana Campaign.*

Carmen Scalise, P.E. *is a Principal Civil Engineer with MWRDGC serving as project engineer for the McCook Reservoir and other TARP related projects. He also oversees the District's collection systems asset management plan and associated sewer rehabilitation design projects. He has a Bachelor of Science in Civil Engineering and a Masters of Public Works from the Illinois Institute of Technology.*

Kevin M. Fitzpatrick, P.E. *is Managing Civil Engineer for the MWRDGC overseeing engineering for all of the District's collection facilities projects, which includes the $3.8 billion Tunnel and Reservoir Plan (TARP), as well as intercepting sewer rehabilitation work. He has a Bachelor of Science in Civil Engineering from the University of Illinois and a Master of Science in Environmental Engineering from the University of North Carolina.*

Kevin Coburn *has been a business development manager for Insituform Technologies for the past 19 years. He works with customers to find solutions to their challenges in both sewer and water pipelines. Insituform invented Cured in Place Pipe in 1971 and their process is used worldwide to rehabilitate gravity and pressure pipes from 6" to 96" diameter. Kevin is based out of Orland Park and covers Illinois.*